Science Organising Committee

Katherine Joy (Chair)
Romain Tartese
Mahesh Anand
John Pernet-Fisher
Kerri Donaldson-Hanna
Evelyn Furi
Jessica Flahaut
Greg Schmidt
James Carpenter

Local Organising Committee

Romain Tartese (Chair)
Katherine Joy
Patricia Clay
Samantha Bell
Vera Assis Fernandes
John Pernet-Fisher
Sarah Crowther
Gemma Coleman

europlanet Science & Technology Facilities Council esa SERVI MANCHESTER 1824 The University of Manchester

Updated: 9th May 2019

European Lunar Symposium
Manchester 2019

Meeting information

Welcome you to Manchester for the 7th European Lunar Symposium (ELS). We are hoping to have a great meeting, demonstrating the diversity of the current lunar research in Europe and elsewhere, and continuing to provide a platform to the European lunar researchers for networking as well as exchanging news ideas and latest results in the field of lunar exploration.

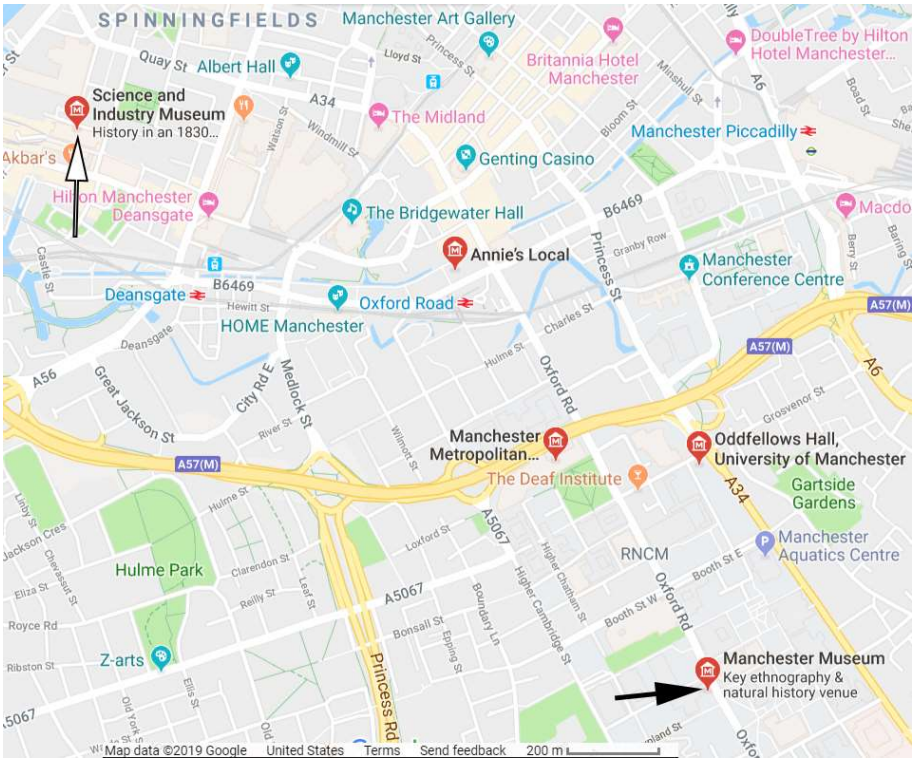
We gratefully acknowledge the support of the University of Manchester, NASA SSERVI, the Royal Astronomical Society, the Science and Technology Facilities Council, Europlanet, and the European Space Agency. Our special thanks to our SSERVI colleagues Kristina Gibbs, Jennifer Baer, Maria Leus, and Ashcon Nejad, and to Gemma Coleman at the University of Manchester for their contribution to the meeting preparation and program implementation.

Members of the Science Organising Committee are thanked for their input in putting together an exciting program and for volunteering to chair various sessions in this meeting.

Meeting Venue

Please note that there are two different venues:

- The reception event on the 20th May will be held at the Manchester Museum in the south of the city, close to the University of Manchester. This will start at 18:00 and will go on until 21:00.
- The symposium on 21st-23rd May will be held at the Science and Industry Museum – Garratt suite conference facilities.



Conference venue: *Science and Industry Museum, Liverpool Rd, Manchester M3 4FP, UK – https://goo.gl/maps/PwEbepjPf7k (white arrow in map); https://www.scienceandindustrymuseum.org.uk/*
Registration event: *Manchester Museum, University of Manchester, Oxford Rd, Manchester, UK – https://goo.gl/maps/8xX4UYSr86J2 (black arrow in map); https://www.museum.manchester.ac.uk/*

Registration

All participants should register and collect their name badges and conference material at the registration/help desk on at the Manchester Museum on Monday 20th May evening (17:30 – 21:00) or on Tuesday 21st May (preferably between before 09:15) at the Museum of Science and Industry.

Refreshments

We will provide coffee, tea, water, juice, and cookies during 'coffee breaks' in the Garratt foyer outside the conference room. Lunch on the Tuesday and Wednesday will also be served in the Garratt foyer. Dinners will not be provided, but light snacks will be available Tuesday and Wednesday evening.

Presentations

All oral presentations will take place in the Science and Industry Museum Garratt Auditorium. Posters will be presented in the Science and Industry Museum Garratt foyer area on the Wednesday night.

Those presenting talks are encouraged to upload their presentation on the designated computers in the Auditorium as early as possible to ease the organisation and to avoid any delays in the schedule. Those presenting in the mornings, please come to the "Auditorium" no later than 8:50 am to ensure your talk is loaded ok. Those presenting in the afternoon session, please upload your presentation during lunch break. At the very latest, all presenters should have uploaded their presentations during the preceding refreshment/lunch break prior to their session. Presentations should be provided both in Microsoft PowerPoint and PDF formats. Any delay caused by technical problems will be taken out from your presentation time. We would prefer that you do not use your own computers to run presentations.

Each speaker (unless specifically indicated otherwise) will have a 15 minute slot allocated in the timetable. A maximum of 12 min will be allocated to the actual presentation, with 3 min for Q&A and change-over.

For posters please make them in A0 **vertical** format as the poster boards are 1 m wide by 2 m high. Your poster can be put up on the Tuesday prior to the poster session Wednesday evening.

Provisional programme *(subject to change)*

Monday 20th May 2019

Welcome reception: European Lunar Symposium Welcome Event from 17:30 to 21:00, held at the Manchester Museum (https://www.museum.manchester.ac.uk/). Please join us at the Manchester Museum for a welcome drinks reception and symposium registration.

Public talk: Public talk from 18:00-19:00 held at the University Place, University of Manchester, by Dr Jim Green, NASA Chief Scientist, on '**The Importance of the Moon: Past, Present and Future**'. This talk has limited capacity. If you wish to attend y*ou will need to register separately for a free ticket* at https://theimportanceofthemoon.eventbrite.co.uk (please note that this event is currently sold out). This talk will be in the building opposite the registration / welcome event.

Tuesday 21st May 2019

From	Duration (minutes)	Lead author	Title
09:00	15		Coffee served in Garratt Foyer
09:15	15	Romain Tartese, Mahesh Anand & Greg Schmidt	Welcome
Agency session – Garratt Suite	Session Chairs: Mahesh Anand and Greg Schmidt		
09:30	10	James Carpenter	Lunar exploration in ESA's European exploration envelope programme
09:40	10	Jim Green	US Space Policy Directive -1
09:50	10	Steve Clarke	NASA's lunar discovery and exploration program
10:00	10	Sue Horne	The UK Space Agency's exploration programme
10:10	10	Mariya Danilova	Russian lunar exploration strategy and current activities
Agency Panel	Panel facilitators: Mahesh Anand and Greg Schmidt		
10:20	30		James Carpenter, Jim Green, Steve Clarke, Ben Bussey, Sue Horne, Yangting Lin, Mariya Danilova
10:50	20		Refreshments in Garratt Foyer
Session 1: Outstanding lunar science questions as drivers for exploration			
Session Chair: Katherine Joy			
11:10	30	Tim O'Brien	Keynote: Manchester's Jodrell Bank Telescope's role in lunar exploration programme
11:40	15	Ben Bussey	Exploration of the Moon as an enabler of Solar System science
12:55	15	Yangting Lin	Formation and evolution of the Moon: the key questions addressed by future lunar missions.
12:10	1 hour 10 mins		Lunch in Garratt Foyer
Session 2: Sample return enabled by exploration			
Session chairs: Alice Stephant and John Pernet-Fisher			
13:20	30	Grenville Turner	Keynote: Looking back 50 years to Apollo 11
13:50	15	Ryan Zeigler	Five decades of insight into Solar System processes from the Apollo sample suite: A guide to future exploration
14:05	15	Dayl Martin	ESA's Sample Analogue Curation Facility, and expanding ESA's Exploration Sample Analogue Collection

Session 3: Early geological evolution of the Moon			
Session chairs: Alice Stephant and John Pernet-Fisher			
14:20	15	Alessandro Morbidelli	Sequestration of highly siderophile elements into the lunar core during a late magma ocean crystallization and mantle overturn
14:35	15	Barbara Cohen (talk by Natalie Curran)	Constraining Solar System bombardment using samples and *in situ* radiometric dating
14:50	15	David Kring	An iterative step in assessing the relative contributions of accreting asteroids and comets to the Moon during the first billion years
15:05	20		Refreshments in Garratt Foyer
15:25	15	Maxwell Thiemens	Investigating the Moon through a Hf/W lens
15:40	15	John Pernet-Fisher	Trace-element systematics of highland anorthosites: Implications for understanding the formation of the lunar crust
15:55	15	Joshua Snape	Experimental and analytical constraints on lunar magma ocean crystallisation
16:10	15	Martijn Klaver	Tracing lunar magma ocean crystallisation with Mg-Ca isotope systematics of mare basalts
16:25	15	Claudia Pöhler	Age and origin of the lunar northern light plains
16:40	15	Nicolle Zellner	Lunar impact glasses: Probing the Moon's surface and constraining its impact history
16:55	15	Rachel Klima	Integrating near and mid infrared data to examine mafic minerals around the Imbrium, Apollo, and Moscoviense basins
17:10	20		Refreshments kindly sponsored by ESA
17:30-19:30	2 hours		ESA night* – panel discussion between the science community and representatives of ESA

*ESA night provides an opportunity to pose questions to a panel of ESA representatives, including those from the European Astronaut Centre and the Directorate for Human Spaceflight and Robotic Exploration. It is a chance to learn more about ESA's strategy for lunar science and prospective lunar exploration, its strategy for in situ resource utilisation, and more. In turn, ESA is keen that its Moon activities are reflective of the lunar community and encourages feedback as well as questions. With this in mind, remember to bring your mobile phones.

Wednesday 22nd May 2019

From	Duration (minutes)	Lead author	Title
09:00	15		Coffee served in Garratt Foyer
Session 4: Lunar volcanism			
Session Chairs: Patricia Clay and Samantha Bell			
09:15	15	Timothy Fagan	Magmatic stages within olivine cumulate gabbro of the NWA 773 clan and volatile elements in residual liquids recorded by apatite
09:30	15	Samantha Bell	Crystal size distribution analysis of Apollo 15 mare basalts: new methods and some recommendations
09:45	15	Lisa Gaddis	Mineralogy of small lunar volcanoes: Eruption styles of pyroclastic deposits inferred from Moon Mineralogy Mapper data
10:00	15	Lionel Wilson	Duration and significance of volcanically-induced transient atmospheres on the Moon
10:15	15	Ian Crawford	Implications of an early lunar atmosphere

10:30	15	Wajiha Iqbal	Geological mapping and absolute model ages around the Apollo 17 landing site
10:45	20		Refreshments in Garratt Foyer
Session 5: Impacts, surface processes and volatiles			
Session chairs: Kerri Donaldson-Hanna and Vera Assis Fernandes			
11:05	15	Samuel Halim	Assessing the survivability of terrestrial material impacting the lunar surface
11:20	15	Roberto Bugiolacchi	A new map of thermal variations with depth within Copernicus crater using Chang'e-2 (CE-2) microwave radiometers (MRMS) data
11:35	15	Emerson Speyerer	Examining the impact process with photometric image sequences
11:50	15	Angela Stickle	Lunar crater ejecta maturation across wavelength
12:05	15	Carolyn van der Bogert	Recent events at the Apollo 17 landing site: Ages of the Lee Lincoln scarp, light mantle deposit, and Tycho crater
12:20	15	Jaclyn Clark	Fault slip movement along wrinkle ridge-lobate scarp transitions in the last 100 Ma
12:35	1 hour		Lunch in Garratt Foyer
Session 5 continued: Impacts, surface processes and volatiles			
13:35	15	Alice Stephant	Hydrogen isotopic signature of the Moon as recorded in melt inclusions
13:50	15	Joshua Cahill	The unusual Atlas/Hercules region of the Moon
14:05	15	Ben Greenhagen	Groundtruthing laboratory experiments with Diviner lunar radiometer observations
14:20	15	Kerri Donaldson Hanna	The Moon and asteroids at thermal infrared wavelengths
14:35	15	Carle Pieters	Ingenii farside swirls have everything (except access)
14:50	15	Gerald Patterson	Mini-RF radar observations of polar craters: Are they rough, smooth, or icy?
15:05	20		Refreshments in Garratt Foyer
Session 6: Prospecting and ISRU			
Session Chairs: Ian Crawford and Bethany Lomax			
15:25	15	Elliot Sefton-Nash	Targeting lunar volatiles with ESA's PROSPECT payload
15:40	15	Simeon Barber	In-situ studies of the lunar water cycle by ion trap mass spectrometry
15:55	15	James Mortimer	An experimental approach to understanding sublimation water ice losses from planetary regolith analogue mixtures for ESA's PROSPECT package
16:10	15	Tristram Warren	The Oxford 3D thermophysical model with application to PROSPECT on the Luna-27 lunar lander mission
16:25	15	Yang Gao	Lunar "Volatile And Mineralogy Mapping Orbiter" (VMMO) mission
16:40	15	Yoshifumi Futaana (talk to be given by Tony Cook)	The mission SELPHIE to investigate lunar water
16:55	15	Timothy Livengood	Submillimeter Solar Observation Lunar Volatiles Experiment (SSOLVE)
17:10	15	Bob Lamboray	Luxembourg's Space Resources Initiative
17:30-20:00	2.5 hours		Poster session with refreshments kindly sponsored by ESA and the Science and Technology Facilities Council

Thursday 23rd May 2019

From	Duration	Lead author	Title
09:00	15		Coffee served in Garratt Foyer
Session 6: Prospecting and ISRU			
Session Chairs: Hannah Sargent and Gunter Just			
09:15	15	Ryan Timoney	Lunar subsurface exploration technologies at the University of Glasgow: Capabilities and the 'i-Drill' case study
09:30	15	Hannah Sargeant	Experimental development and testing of the reduction of ilmenite for a lunar ISRU demonstration with ProSPA
09:45	15	Philipp Reiss	Thermogravimetric analysis of chemical reduction processes for the in-situ production of oxygen from lunar regolith
10:00	15	Laura Grill	Fluidisation of lunar regolith simulants for ISRU applications
10:15	15	Sungwoo Lim	Microwave heating experiment of lunar simulant (JSC-1A) using a bespoke industrial microwave apparatus
10:30	15	Aidan Cowley	Spaceship EAC – Progress on current activities for lunar construction and oxygen production ISRU
10:45	20		Refreshments in Garratt Foyer
Session: Future mission concepts and architectures			
Session Chairs: James Carpenter and Romain Tartese			
11:05	15	Emily Law	Applications and planning for lunar laser retroreflector studies
11:20	15	John Vrublevskis	Using the European Space Agency (ESA) technology developed for Mars return for a Moon cryo-sample return
11:35	15	Jonathan Friend (talk given by Nelly Offord Harlé)	Commercial Lunar Missions Support Services (CLMSS) programme
11:50	15	Iannis Dandouras	Space plasma physics science opportunities for the Deep Space Gateway
12:05	15	Harald Hiesinger	Returning to the Moon with HERACLES
12:20	30	Mark McCaughrean (ESA)	ESA's planetary missions – once explorers, always explorers
12:50	10	Mahesh Anand and Greg Schmidt	Closing remarks
13:00			Meeting ends

Thursday afternoon optional trip to visit Jodrell bank radio telescope. See the ELS 2019 website (https://els2019.arc.nasa.gov/) for details on how to register and pay for this visit and the final page of this programme for more information for those participating.

Poster Presentations

#	Lead author	Poster title
Topic: ISRU		
1	Athanasios Goulas	Laser additive manufacturing using indigenous lunar resources
2	Beth Lomax	The Metalysis-FFC-Cambridge process for efficient production of oxygen and metals on the lunar surface
3	Gunter Just	Critical review of regolith excavation techniques for lunar in situ resource utilisation and suggested experimental parameters
4	Kathryn Hadler (presented by Dayl Martin)	A universal flowsheet and terminology for in situ resource utilisation (ISRU)
5	Levi Turk	Novel approaches to ISRU: Aqueous alkaline phase electrolytic regolith reduction and other work at Spaceship EAC
Topic: Lunar geology		
6	Claudia Pöhler	Geological mapping of the South Pole Aitken Basin: A progress report
7	Daniel Wahl	Bulk density and porosity of the upper lunar crust from high-resolution GRAIL and LOLA data
8	Danil Borisov (presented by Wajiha Iqbal)	Revised crater size-frequency distribution measurements at the Apollo 14 landing site
9	Giulia Magnarini	Friction experiments on iron sulfide-bearing anorthosite and implications for mechanism of long runout landslides on the Moon
10	John Pernet-Fisher	Halogen (Cl, Br, I) systematics of lunar ferroan anorthosites: Evidence for sub-chondritic lunar volatiles
11	Kathryn McCanaan	Exploring the lunar regolith at the microscale
12	Marissa Lo	Determining the volatile history of the Moon through geomorphological studies of eruption deposits and modelling of volcanic processes
13	Natalie Curran	Impact-melt sample populations in Apollo drive-tube 68001/68002
14	Nian Wang	Mineralogical characteristics of U-Pb datable minerals in lunar meteorite Northwest Africa 2995: Implication for its multi-impact history
15	Peter Cadogan	Precision counting of very small craters at lunar landing sites
16	Tara Hayden	Petrography and mineralogy of igneous clasts in lunar meteorite NWA 11228
17	Thomas Harvey	Geochemical and textural comparison of metal particles in lunar and asteroidal meteoritic samples: A window to impactor chemistry
18	Urs Mall	Lunar rock boulders as a tool in comparative planetology to investigate rock weathering
19	Wajiha Iqbal	New geological maps of the Apollo 11 and 12 landing sites
20	Zoe Morland	Metal impactor fragment found in lunar regolith breccia meteorite North West Africa 10989
Topic: Spectroscopy		
21	Isabel Haase	Bundle adjustment of LROC NAC stereo images for high precision DTMs and maps
22	Jennifer Grier	Examining issues effecting the apparent optical maturity of impact craters
23	Joshua Cahill	Scrutinizing the presence of lamp identified lunar swirls relative to modeled magnetic sources
24	Martin Burgdorf	Disk-integrated lunar brightness temperatures at infrared (6-12 microns) and mm-wavelengths (1.6-3.4 mm)
25	Patrick Pinet	Advanced spectroscopic software for olivine detection and composition determination
26	Rowan Curtis	Towards understanding the role of scattering in thermal transfer on the Moon using the Oxford space environment goniometer
27	Serge Chevrel	Large impact craters: Linking spectral composition (M3) and morphological features at high resolution (LRO).

Topic: Missions / instruments		
28	Alexander Verchovsky (presented by Mahesh Anand)	A quantitative evolved gas analysis for lunar and meteoritic materials
29	Christian Schröder	MIMOS II – an off-the-shelf miniaturized Mössbauer spectrometer for in situ lunar exploration and ISRU
30	Christian Schröder	MIMOS IIa – advanced miniaturized Mössbauer spectrometer for rapid spectral acquisition and with potential X-ray fluorescence capability
31	Gilles Bailet	SIRONA1 – a SelenocentrIc platfoRm hOsting iNternational pAyloads
32	Janos Biswas (presented by Philipp Reiss)	Characterization of the lunar volatiles scout for in-situ volatiles extraction and analysis
33	Kerri Donaldson Hanna	Moon Diver: A discovery mission concept for understanding secondary crust formation through the exploration of a lunar mare pit cross-section
34	Simon Sheridan	Characterisation of the LUVMI volatile extraction and volatiles analysis package
35	Sylvain Ranvier	Dust study, transport, and electrostatic removal for exploration missions: The DUSTER project
36	Jean-Charles Matéo Vélez	Improving our knowledge of lunar sub-surface and internal structure and composition with gradiometers and gravimeters

Jodrell Bank Visit - Thursday 23rd May

Jodrell Bank Discovery Centre will be open to the public during our visit so there will be other visitors there too, including groups of school children.

Our visit will comprise a talk about Jodrell Bank, and time to explore the Discovery Centre and gardens. All being well, we hope to also include a behind the scenes tour of the telescope control room, something which is not usually available to visitors.

There is a café in the Discovery Centre where food and drinks can be purchased. There is also a shop where gifts can be purchased.

Travel to/from Jodrell Bank

- We will travel to Jodrell Bank in Cheshire by coach. The journey to/from Jodrell Bank will take 45 mins to an hour depending on traffic.
- Coach will depart from outside the Science and Industry Museum at **13:30**.
- Return coach will depart from Jodrell Bank at **17:00**. The coach will return to the Science and Industry Museum, and we should be back in Manchester around 18:00.

Use of mobile phones

- Mobile phones **must not** be used to send or receive calls/messages/internet at Jodrell Bank **for any reason**. Mobile phones must be switched to flight mode, or switched off whilst on site. This is a condition of visiting Jodrell Bank. Mobile phone signals interfere with the workings of the radio telescopes on site; interrupting the scientific research.
- If for any reason you need to use a telephone, please speak to a member of staff at the Discovery Centre, and they will direct you to a landlines, which you will be welcome to use.
- Please give anyone who may need to contact you the telephone number for the Discovery Centre, +44 (0)1477 571 766. The Discovery Centre staff will relay any messages.
- Phones can be used to take pictures, etc., provided they are set to flight mode.

In case of an accident or emergency

- There are first aiders on site at all time, so in the event of injury please contact a member of the Discovery Centre staff.
- Fire-marshal trained staff are present in each building. In the event of a fire alarm they will direct visitors to the nearest muster point.

If you have any medical issues or access requirements which may impact on your enjoyment of this visit please speak to Dr Sarah Crowther before Thursday so we can discuss how we can accommodate your needs.